(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 421 718 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 90310752.2

(22) Date of filing: 02.10.90

(51) Int. Cl.5: B41J 2/04

(30) Priority: 03.10.89 US 416796

(43) Date of publication of application: 10.04.91 Bulletin 91/15

(84) Designated Contracting States: DE FR GB

(71) Applicant: XEROX CORPORATION
Xerox Square - 020
Rochester New York 14644(US)

(72) Inventor: Khuri-Yakub, Butrus T.
4151 Donald Drive
Palo Alto, California 94306(US)
Inventor: Elrod, Scott A.
2139 Ashton Avenue
Menlo Park, California 94025(US)
Inventor: Quate, Calvin F.
859 Cedro Way
Stanford, California 94305(US)

(74) Representative: Weatherald, Keith Baynes et al
Rank Xerox Patent Department Albion House, 55 New Oxford Street
London WC1A 1BS(GB)

(54) Ink drop printhead.

(57) An acoustic ink printhead (10′) having improved ink drop ejection control includes a substrate (12) having an array of acoustic lenses (20) at its upper surface (22) for bringing rf acoustic waves to a predetermined focus, and a layer (50) of acoustically-reflective material of a thickness equal to an odd multiple of one quarter of the wavelength of the acoustic rf waves passing through it, the layer having openings corresponding to and aligned with each lens. Ink from an ink pool is allowed to couple acoustically to the lenses at each opening for receiving the focussed acoustic rf wave, while the layer acoustically isolates the interstitial regions between each lens by reflecting the acoustic rf waves incident on the upper surface of the substrate in those regions.

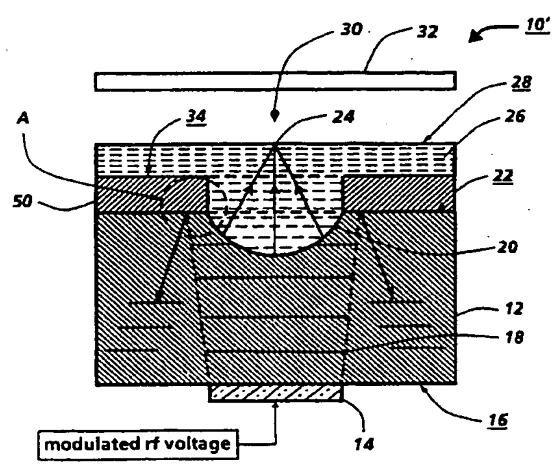


Fig. 2

EP 0 421 718 A1

The present invention relates generally to acoustic ink printing, and more particularly to a printhead having an acoustic reflection coating applied thereon to reduce unwanted transmission of acoustic energy into an ink pool.

Acoustic ink printing (or marking) is a method for transferring ink directly to a record medium, having several advantages over other direct printing methodologies One important advantage is the lack of necessity for nozzles and ejection orifices that have caused many of the reliability (e.g., clogging) and picture element (i.e., pixel) placement accuracy problems which conventional drop-on-demand and continuous-stream ink jet printers have experienced.

As is known, an acoustic beam exerts a radiation pressure against objects upon which it impinges. Thus, when an acoustic beam impinges on a free surface (e.g., liquid/air interface) of a pool of liquid from beneath, the radiation pressure which it exerts will cause disturbances on the surface of the pool. The radiation pressure may reach a sufficiently high level that the force of surface tension is overcome and individual droplets of liquid are ejected from the pool. Given sufficient energy, the droplets may eject at a sufficient speed to reach a record medium located near to the free surface of the pool.

Focussing the acoustic beam on or near the surface of the pool intensifies die radiation pressure it exerts for a given amount of acoustic power. In order to accomplish such focussing, acoustic lenses are commonly used. These lenses conveniently are essentially at concave indentations in a substrate through which the acoustic beam may travel. One or more such lenses may be disposed in a single substrate, and each of the lenses may be individually addressable. See, for example, US-A-4,751,529, and 4,751,534, for further discussion of acoustic lens characteristics.

Referring now to Figure 1 of the accompanying drawings, there is illustrated (in pertinent part) an acoustic ink printhead 10 of a known design. Acoustic ink printhead 10 includes a body or substrate 12. An acoustic wave generator 14, typically a planar transducer, for generating an acoustic wave of predetermined wavelength, is positioned on a lower surface 16 of substrate 12. Lower (and the like) is used herein for convenience and no limitation on orientation is intended thereby. Transducer 14 is typically composed of a piezoelectric film (not shown), such as of zinc oxide (ZnO), which is sandwiched between a pair of electrodes (also not shown), or other suitable transducer composition such that it is capable of generating plane waves 18 (explicitly shown in Fig. 1 for illustration) in response to a modulated rf voltage applied across its electrodes. Transducer 14 will typically be in mechanical communication with substrate 12 in order to facilitate efficient transmission of the generated acoustic waves into the substrate.

Acoustic lens 20 is formed in the upper surface 22 of substrate 12 for focussing acoustic waves 18 incident on its convex side to a point of focus 24 on its concave side. Upper surface 22 as well as the concave side of acoustic lens 20, face a liquid pool 26 (preferably an ink pool) which is acoustically coupled to substrate 12 and acoustic lens 20. This acoustic coupling may be accomplished by placing the liquid of liquid pool 26 in physical contact with acoustic lens 20 and upper surface 22, or by introducing between the liquid of liquid pool 26 and acoustic lens 20 and upper surface 22 an intermediate acoustic coupling medium (not shown). Such intermediate acoustic coupling media are discussed in the aforementioned US-A-4,751 ,534..

When a printhead is formed having adjacent acoustic lenses, especially when the adjacent lenses are individually addressable, care must be taken to direct the acoustic beam accurately to impinge as exclusively as possible on the desired lens. Some of the undesirable effects of the acoustic beam impinging elsewhere than on the desired lens are insufficient radiation pressure on the liquid surface, lens cross-talk, and generation of unwanted liquid surface disturbances. Each of these effects result in loss or degradation of droplet ejection control. The present invention primarily addresses the effect of generation of liquid surface disturbances.

As graphically shown in Fig. 1, plane waves 18 diverge as they radiate through the substrate from transducer 14 to upper surface 22. This divergence is because of the effect of diffraction of the sound wave passing through the substrate, and is a function of the radius of the transducer 14, of the thickness of the substrate, and of the wavelength of the wave passing through the medium. (It is generally assumed that the interface between substrate 12 and transducer 14 is ideal, so that consideration need not be given to the refractive effects of the wave passing from one medium to another, and further that transducer 14 generates a perfect plane wave.) The result of this divergence is to limit the center-to-center distance between adjacent lenses (if lenses are too closely spaced the diverging energy from one lens may impact an adjacent lens) and to cause energy to impinge upper surface 22 outside of lens 20 which may be imparted in the form of acoustic waves (not shown) into liquid pool 26.

Focus point 24, at or very near free surface 28, is the point of greatest concentrated energy for causing the release of droplet 30. Thus, by positioning the focus point 24 at the free surface 28,

the energy required to eject a droplet is minimized. However, focus point 24 is preset for each lens by the lens diameter, shape, etc. In order to maintain focus point 24 at or very near the free surface 28, it is therefore important to maintain the free surface 28 at a predetermined height above substrate 12.

As mentioned, one effect of irradiation of surface 22 is transmission of radiant energy from substrate 12 to liquid pool 26. The radiant energy is transmitted through the liquid of liquid pool 26 striking free surface 28, thereby generating surface disturbances on free surface 28. These surface disturbances are transmitted along free surface 28 in the form of surface waves (not shown) which affect free surface 28 in regions directly above lens 20. In those cases where an array of lenses is used, the surface waves affect free surface 22 in regions above one or more acoustic lenses. The surface waves on free surface 28 result in deviation of free surface 28 from planar and from a preferred height, thereby altering the location of free surface 28 relative to fixed focus point 24, resulting in degradation of droplet ejection (i.e., print) control.

The result of free surface 28 deviating from planarity is varying angle of droplet ejection. Droplets will tend to eject in a direction normal to free surface 28. For optimum control of placement of the drop on the record medium with the minimum amount of required acoustic energy, it is desired to maintain ejection angle of the drop at a predetermined value, generally perpendicular to the local angle of the surface of the record medium. Therefore, attempts have been made to maintain free surface 28 parallel to the primary surface of the record medium. Surface disturbances will vary the local surface angle of the liquid pool, especially over the acoustic lenses. This results is drop ejection at varying angles, with consequent loss of printing accuracy and efficiency.

The result of free surface 28 varying from a preferred height is an increase in the energy required to cause droplet ejection and an adverse effect on droplet size and droplet ejection direction control. In fact, surface height must be maintained with high accuracy, since acoustic waves entering liquid pool 26 will also reflect at free surface 28, resulting in coherent interference between the reflected and unreflected waves. The boundary conditions on free surface 28 for resonant constructive interference and anti-resonant destructive interference differ from each other by only one quarter of a wavelength. The effect of constructive interference is to exacerbate the surface-disturbing effects of energy transmitted into liquid pool 26 outside lens 20.

Although it is possible that transducer size may be selected such that irradiation outside lens 20 is minimized, changing transducer size impacts divergence of the wave in the substrate. For example, acoustic wave divergence effectively begins in a material after the distance d defined as

$$d = R^2/\lambda \qquad (1)$$

where R is the radius of the transducer and

$$\lambda = v_m/f \qquad (2)$$

where v_m is the speed of sound in the material, and f is the frequency of the sound wave. If the transducer radius is decreased in order to reduce the size of the cone of divergence, the distance d from the transducer at which the divergence of the acoustic waves begins will be reduced. If the substrate thickness remains unchanged, decreasing transducer size (and hence reducing d) results in greater divergence. Thus, reducing the transducer size implies a reduction in substrate thickness. However, the thickness of the substrate is limited by its ability to support itself without cracking. This minimum thickness is on the order of 0.5-2mm, and effectively limits the transducer size.

Similarly, it is possible to increase the radius of the acoustic lenses such that the diverging acoustic waves impinge fully on the lens. Typically, however, lens-to-lens spacing is much larger than the printed spot size. Thus, an array of lenses in staggered rows is often used for single-pass printing. The result of increasing the center-to-center spacing is an increase in the number of staggered rows for a fixed print resolution. This is not desirable since it means that the printhead size (i.e., substrate size) and cost will both increase. Thus, this also is not an optimal solution.

Presently there is an unaddressed need in the art for improved performance of acoustic ink printing mechanisms. Specifically, there is a need in the art for a method and apparatus for reducing surface disturbances at the free surface of the ink pool above one or more acoustic lenses. The invention described and contained herein addresses this and related needs in the art.

The present invention provides an improved printhead for acoustic ink printing. The printhead is of the type having one or more acoustic radiators for radiating a free surface of a pool of liquid, typically ink, with a corresponding number of focused acoustic beams and being characterized by having a predetermined coating for inhibiting extraneous acoustic energy from coupling into the liquid peripherally of the beam or beams.

Specifically, the acoustic ink printhead of this invention includes:

a solid substrate having a first, or upper, surface with generally concave indentations therein to define acoustic lenses, and a second, or lower, surface opposite the upper surface;

a transducer intimately coupled to the lower surface of the substrate for generating rf acoustic waves to irradiate the lenses, such that the lenses

launch respective converging acoustic beams into the liquid, and

acoustic reflectors intimately coupled to, and substantially entirely overlaying the upper surface of, the substrate except above the lenses wherein openings above each of the lenses are defined, for inhibiting extraneous acoustic energy from coupling into liquid of a liquid pool above the upper surface other than at the lenses.

According to one aspect of the invention, the coating material will have a relatively high acoustic impedance compared with the material from which the substrate is formed. To this end, gold has been shown to have desirable properties as a reflective material.

According to another aspect of the invention, the coating will be of a predetermined thickness, preferably equal to one-quarter of the wavelength of the acoustic waves passing through it. However, the coating may be of other thicknesses, preferably equal to odd multiples of one-quarter of the wavelength of the acoustic waves passing through it.

The present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows an acoustic ink printhead of a known design;

Figure 2 shows one embodiment of an acoustic ink printhead according to the present invention;

Figure 3 schematically illustrates the transmission and reflection of acoustic waves in various levels in the embodiment shown in Figure 2;

Figure 4a is an illustration of a test structure, and Figure 4b is a plot of frequency versus insertion loss for the structure of Figure 4a, illustrating determination of optimum operating frequency, and

Figure 5a is an illustration of a test structure having a gold coating applied thereto, and

Figure 5b is a plot of frequency versus insertion loss for the structure of Figure 5a, illustrating the effects of a gold coating.

Referring now to Fig. 2, there is shown a printhead 10′ according to a preferred embodiment of the present invention. As with printhead 10 described with reference to Fig. 1, printhead 10′ includes a substrate 12, with an acoustic lens 20 formed therein. In general, as between Figs. 1 and 2 herein, like elements are numbered with like reference numerals, and the description of each is similar except where otherwise noted.

With reference to Fig. 2, an isolation layer 50 of acoustically-reflective material is introduced which overlays the entirety of, and is preferably in mechanical communication with, upper surface 22, except in the region over lens 20. Isolation layer 50 will thus reside between upper surface 22 and liquid pool 26, except for the regions above lens 20. wherein the liquid of liquid pool 26 is acoustically coupled to substrate 12 by direct physical contact or by communication through an intermediate layer (not shown) of acoustically-transmissive material. Through proper placement and selection of certain desirable characteristics, isolation layer 50 serves to isolate substrate 12 and liquid pool 26 acoustically except in the region of lens 20.

Material selected for isolation layer 50 should exhibit the following desirable characteristics for the reasons enumerated below.

(1) The selected isolation layer material must have a much greater acoustic impedance (Z_i) than the acoustic impedance of the substrate (Z_s). If there is a poor match between the acoustic impedances of two materials in contact with one another, the transmission of acoustic energy between the two materials is inhibited. Reference should be made to Fig. 3, showing in greater detail region A of Fig. 2, which graphically illustrates this effect. The impedance mismatch between substrate 12 and isolation layer 50 will cause attenuation of much of the transmitted energy outside the region above lens 20, by reflecting a portion of the acoustic energy (represented by arrow 102) of the total incident acoustic energy (represented by arrow 100) at upper surface 22. However, some energy will overcome the impedance mismatch and be transmitted in the form of acoustic waves into isolation layer 50 (represented by arrow 104). Thus, when $Z_i \gg Z_s$, most of the acoustic energy incident upon upper surface 22 from transducer 14 is reflected at the isolation layer/substrate interface, and only a small amount of that incident energy is transmitted from substrate 12 to isolation layer 50 and, in turn, available to be transmitted to liquid pool 26.

(2) The selected isolation layer material must have a much greater acoustic impedance (Z_i) than the acoustic impedance (Z_l) of the liquid of liquid pool 26. Similar to (1) above, the impedance mismatching will cause attenuation of the transmitted energy outside acoustic lens 20. Acoustic energy (104) incident upon the interface between the isolation layer and the liquid pool will primarily be reflected as acoustic waves (represented by arrow 106) because of the impedance mismatch between the isolation layer and the liquid. Only a relatively small portion of the acoustic energy (represented by arrow 108) transmitted to isolation layer 50 will be transmitted into liquid pool 26. Thus, when $Z_i \gg Z_l$ transmission of acoustic energy to liquid pool 26 is even further reduced to an acceptable level.

(3) The thickness of isolation layer 50 should be equal to an odd integral multiple of one-quarter of the wavelength ($n\lambda/4$, n = 1,3, 5, ...) of the acoustic waves traveling through it. By selecting the thickness of isolation layer 50 as one-quarter of, or odd multiples thereof, the wavelength of the acoustic waves therein, the transmitted waves (108) at interface 34 are 180° out of phase with the transmitted waves (114) entering the liquid after one round-trip propagation (i.e., internal reflection) in isolation layer 50. Once a steady-state is reached, waves (108) and (114) will add destructively, effectively canceling each other out and resulting in a minimum of signal transmission into liquid 26.

There are three secondary considerations for selection of a material for isolation layer 50 which simplify the process of depositing and patterning the layer and which ensure longevity of the printhead formed according to the present invention, respectively. They are:

(1) Selecting a material which can be deposited by known deposition techniques;

(2) Selecting a material which is compatible with known photolithographic techniques; and

(3) Selecting a material which is highly resistant to the corrosive environment of submersion in a liquid pool (such as an ink pool).

Given each of the above-enumerated primary and secondary considerations, it has been found that gold is a very satisfactory material for use as an isolation layer. Other materials which satisfy the above criteria may be used.

In order to produce the acoustic waves discussed above, transducer 14 is driven by an AC signal modulated at either a single frequency or a broad bandwidth of frequencies. The selection of the modulating frequency or frequencies is governed by several considerations. Primarily, drop size will be determinative.

As mentioned above, acoustic waves will pass through a substrate, having an acoustic impedance Z_s and a liquid pool, the liquid in which having an acoustic impedance Z_l. For such a system it is possible to plot power transmitted through the liquid of the liquid pool as a function of the frequency of the acoustic waves. That is, it is possible to determine what amount of energy emitted from a transducer passes through both the substrate and the liquid pool and ultimately impinges upon the free surface of the liquid pool. Such a plot is shown in Fig. 4b, which shows insertion loss at free surface 428 of liquid pool 426 *versus* operating frequency for the system of Fig. 4a consisting of a zinc oxide transducer 414 exposed to air on one side and in mechanical communication with a silicon substrate 412 on the other. In Fig. 4b,

$$\text{Loss} = -20 \log (P_{out}/P_{in}) \qquad (3)$$

where P_{out} is power out of the liquid pool and P_{in} is power into the substrate, respectively. The point of minimum insertion loss, approximately 200.4 MHz for the system of Fig. 4a, corresponds to the particular choice of transducer and substrate materials, size and relationship. The plot of Fig. 4b demonstrates that the system of Fig. 4a will operate with greater efficiency at certain frequencies than at other frequencies.

A similar plot of loss *versus* frequency for the system of Fig. 5a, including substrate 512, transducer 514 and liquid pool 526 identical to that of Fig. 4a and further including a gold isolation layer 550 is shown in Fig 5b. It is demonstrated in Fig. 5b that loss has been increased at and around the frequency of lowest loss in the system of Fig. 4a (i.e., a system without isolation layer 550). In fact, for the system of Fig. 5a where gold isolation layer 550 has been chosen as one-quarter of the wavelength corresponding to the frequency of minimum loss shown in Fig 4b, the frequency of relative maximum loss for the system of Fig. 5a is the same as the frequency of relative minimum loss for the system of Fig. 4a. This is the result of the destructive combining of acoustic waves discussed above. Thus, by choosing an operating frequency based on a plot such as that shown in Fig. 4b, then choosing an isolation layer thickness of one-quarter of the wavelength corresponding to that frequency, loss will be maximized (i.e., transmission of energy from the substrate into the liquid pool will be minimized).

It will be noted that printheads according to the present invention will include both uncoated regions (in alignment with the acoustic lenses) and coated regions (in the interstitial or peripheral regions between the acoustic lenses). Thus, optimum operating frequency for such a system may be chosen by first picking the type of transducer used, and the resolution (and hence drop size) desired. This will determine what the theoretical operating frequency should be. The acoustic lens system without the isolation layer can then be modeled, resulting in plots of insertion loss as a function of frequency, such as shown in Fig. 4b. From such a plot the actual optimum operating frequency can determined, which in turn will yield the value of $\lambda/4$ (the thickness of isolation layer 50).

In the ideal case acoustic lenses would be driven at a single frequency. However, experience has shown it to be preferable to drive the lenses with a broad bandwidth frequency spectrum based on several factors. Such factors include nonplanarity of upper surface 22, substrate 12 being of varying thickness, etc. In each of these cases, insertion loss *versus* frequency calculated at various points across the transducer will differ. Furthermore, as mentioned , the lenses are very sen-

sitive to variations in the height of liquid pool 26. Experience has also shown that it is not practicable to drive each lens of an array of lenses by its own AC voltage supply (based on cost, size, etc.) Since each AC voltage supply will be required to power more than one acoustic lens it may not be possible to operate each voltage supply at the single optimum operating frequency of each lens. According to a preferred embodiment of the present invention, these difficulties are overcome by operating the AC voltage sources at a broad bandwidth frequency spectrum within a preselected range. In certain embodiments a broad bandwidth spectrum is applied in order to overcome irregularities in transducer geometries. In such embodiments, the bandwidth is selected to be wide enough to cover all the optimum frequencies for all lenses.

The thickness of isolation layer 50, in the case of operation of the voltage supplies at a broad spectrum, can be chosen such that the center frequency of the spectrum has the maximum loss as shown in Fig. 5b. However, thickness is somewhat less crucial in the broadband case. In such a case the reduction in transmission of the acoustic signal from surface 22 is not as large as it is in the single-frequency case. This is because, as evidenced in Fig. 5b, there are frequencies around the center frequency at which there is small loss for the transmission of the acoustic energy. The signal in the case of the structure with isolation layer 50 is attenuated for a larger band of frequencies compared with the case of the structure without isolation layer 50, resulting in larger overall loss for the entire spectrum of input frequencies, with a reasonable amount of latitude in the selection of the thickness of isolation layer 50.

Although a printhead has been described which includes a substrate, a transducer and a single reflective coating, two or more layers of reflective coating having the above-described attributes may be used to reduce further the transmission of energy into the liquid pool outside the acoustic lenses.

Furthermore, although typical acoustic ink printers will include one or more planar transducers and acoustic lenses located on and in a substrate, as discussed above, significant alternatives exist in the art. For example, such an alternative is use of piezoelectric shell transducers, such as described in US-A-4,308,547.

Claims

1. An acoustic printhead (10′) for ejecting droplets of liquid on demand from a free surface ofa liquid pool, comprising:
a solid substrate (12) having first and second surfaces, and having an acoustic lens (20) formed therein;
acoustic wave generating means (14) intimately coupled to the second surface of said substrate for generating rf acoustic waves to irradiate the lens such that the lens launches converging acoustic beams into the liquid, and
acoustic reflector means (50) intimately coupled to, and substantially entirely coating, the first surface of the substrate except in the region proximate the acoustic lens, such as to define an opening corresponding to the position and size of the acoustic lens, for inhibiting extraneous acoustic energy from coupling into the liquid pool other than through the lens.

2. An acoustic printhead (10′) for ejecting droplets of ink on demand from a free surface (28) of a pool (26) of liquid ink, comprising:
a solid substrate (12) having a first surface (22) with a plurality of essentially identical, generally part-spherical indentations (20) formed therein on predetermined centers to define an array of acoustic lenses and interstitial regions therebetween, and a second surface (16) opposite the first surface;
a piezoelectric transducer (14) intimately coupled to the second surface for generating rf acoustic waves to irradiate the lenses such that they launch respective converging acoustic beams into the pool, and
an acoustic reflector means (50), intimately coupled to, and substantially entirely coating, the first surface except in the regions proximate the acoustic lenses thereby to define openings corresponding in position and size to each acoustic lens, for reflecting the acoustic rf waves striking the upper surface of the substrate at the interstices between the acoustic lenses.

3. The printhead of claim 1 or 2, wherein the material of the substrate has a first acoustic impedance, and the material of the acoustic reflector has a second acoustic impedance greater than the first acoustic impedance.

4. The printhead of any preceding claim, wherein the acoustic wave generating means generates rf acoustic waves of a predetermined frequency and wavelength, and further wherein the acoustic reflector means is of a thickness equal to one quarter of the wavelength (or an odd integral multiple thereof) of a selected one of the generated rf acoustic waves.

5. The printhead of any preceding claim 2, wherein the acoustic reflector means is comprised substantially exclusively of gold.

6. The printhead of claim, wherein the acoustic lens is a part-spherical indentation in the first surface of the substrate.

7. An acoustic printhead (10′) having at least one acoustic radiator (14) for bringing an acoustic beam

to focus essentially on a free surface (28) of a pool of (26) liquid such that the acoustic beam exerts a radiation pressure on the free surface, and modulating means coupled to the radiator for modulating the radiation pressure so as to eject individual droplets of liquid from the free surface on demand, and comprising an isolation layer (50) deposited on the printhead facing the free surface; the isolation layer being patterned to permit substantially unimpeded passage of the acoustic beam therethrough, but having an acoustic impedance selected to inhibit acoustic energy from coupling into the liquid peripherally of the acoustic beam.

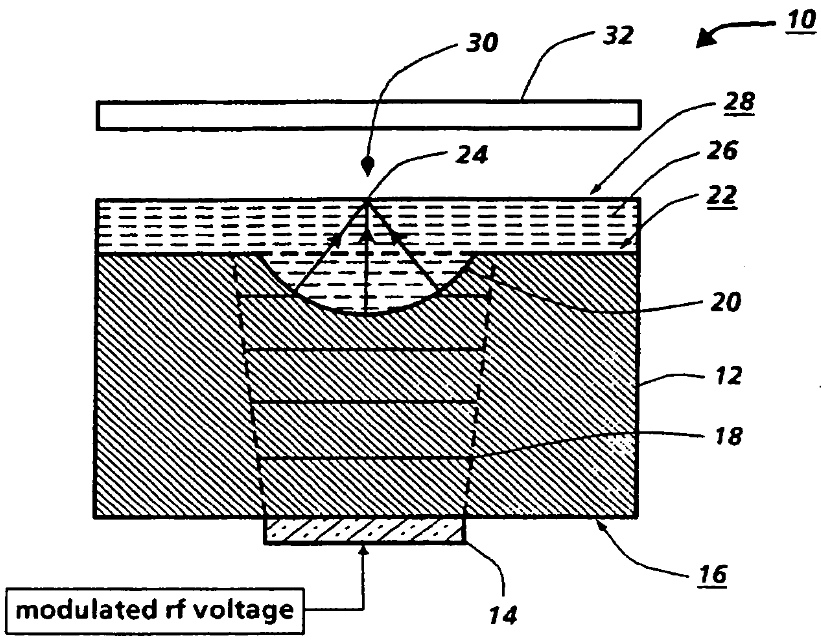


Fig. 1
Prior Art

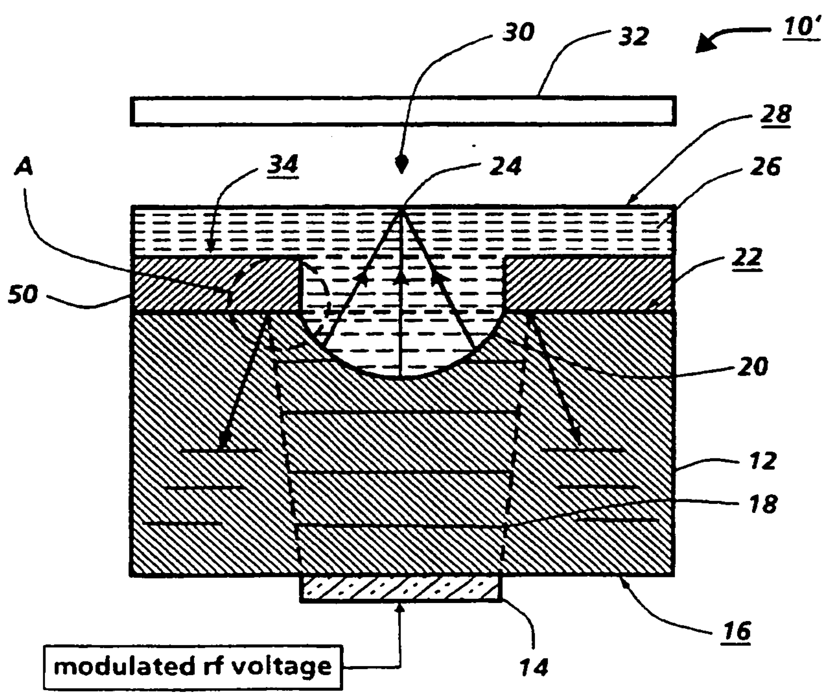
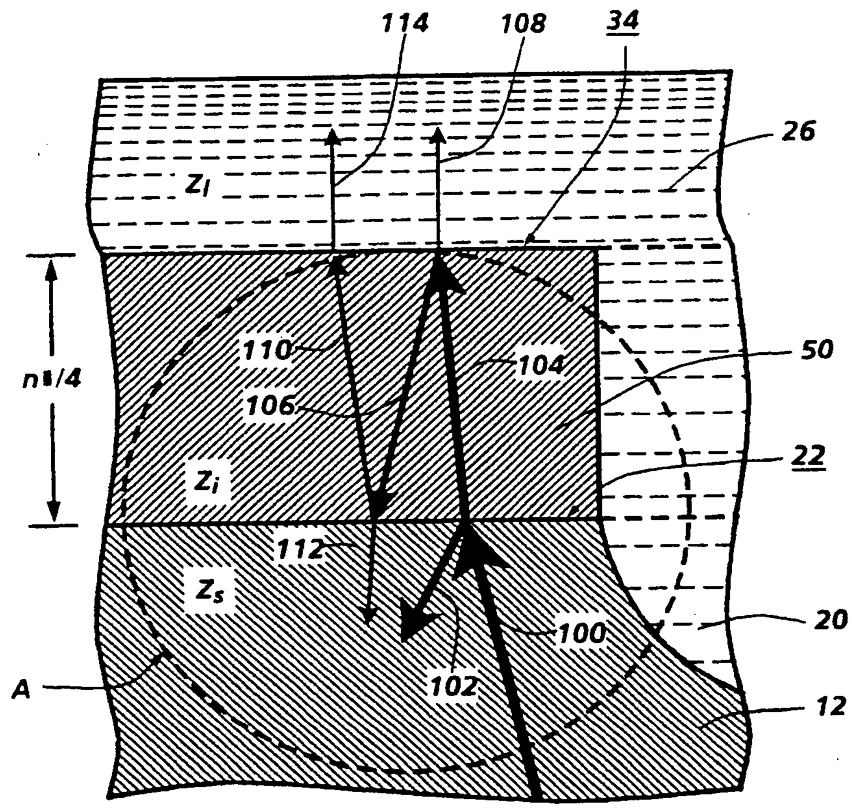


Fig. 2



114
108
34
26
Z_l
110
104
50
$n\lambda/4$
106
22
Z_i
112
Z_s
20
100
A
102
12

Fig. 3

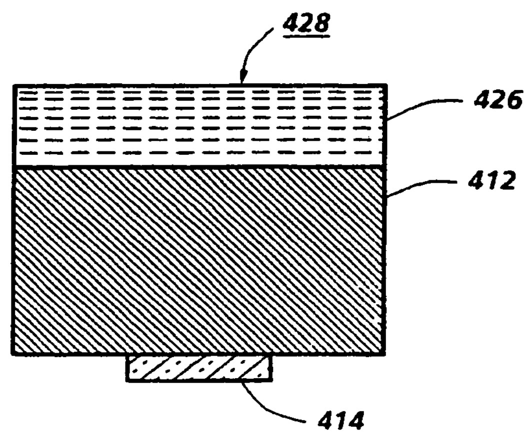

428
426
412
414

FIG. 4a

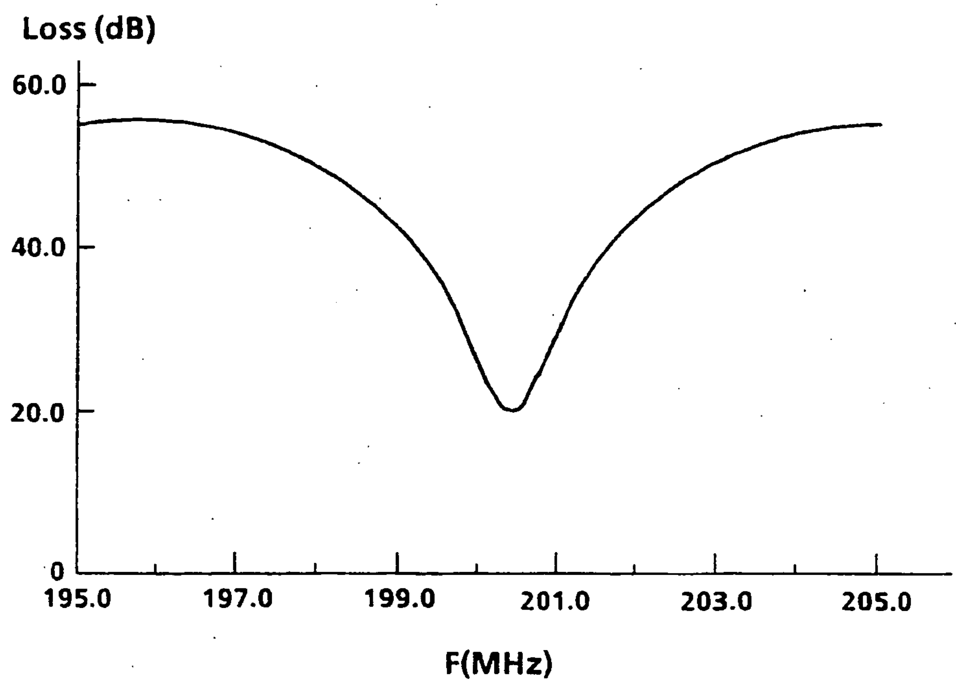

Loss (dB)
60.0
40.0
20.0
0
195.0
197.0
199.0
201.0
203.0
205.0
F(MHz)

FIG. 4b

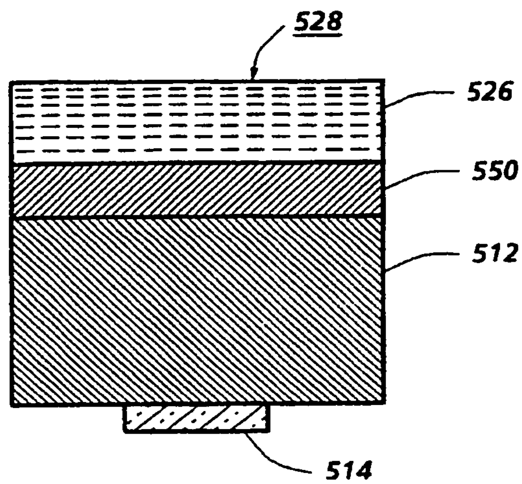

528
526
550
512
514

FIG. 5a

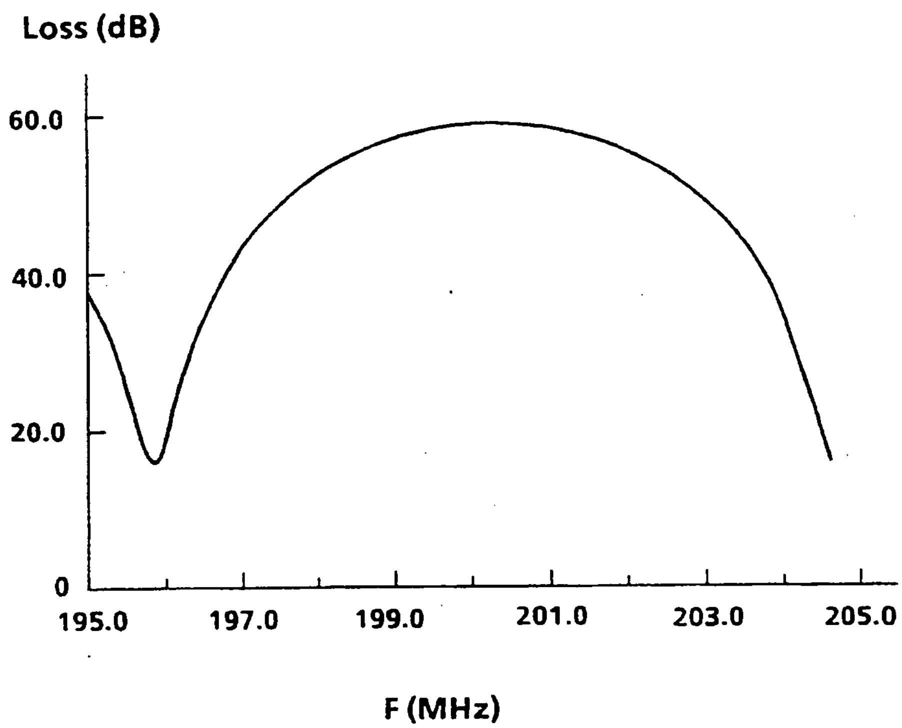

Loss (dB)
60.0
40.0
20.0
0
195.0
197.0
199.0
201.0
203.0
205.0
F (MHz)

FIG. 5b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90310752.2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	US - A - 4 751 529 (ELROD) * Totality * --	1,2,6, 7	B 41 J 2/04
A	EP - A2 - 0 272 899 (XEROX CORP.) * Fig. 1,2 * ----	1,2,6, 7	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
B 41 J G 01 D G 10 K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	08-01-1991	WITTMANN

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)